Status and Development of Geomatics in China

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Abstract   Mechanization is the characteristic of the industrial era and computerization is the characteristic of the Information Era. Now we are facing on the transition from Industrial Era to Information Era. Established the National Geo-spatial Data Infrastructures is the fundamental base for information society and is one part of the national basic economic development plan. From 1980's China started his successful transition from traditional methods to high-tech based mapping. China has laid out a high accuracy national GPS (global Positioning System) network, and completed the geographic information databases for scale of 1:1million and 1:250,000. Now it is working on the databases for scales of 1:50,000and 1:10,000, the world highest level. The massive national programmed has been dubbed "Digital China," since it involves massive quantities of digitized geographical information. Simultaneity, GIS technology and the geo-spatial data have been used widely in electronic government affair, environmental protection, disaster control, ITS and etc. The users have realized the benefits more and more widely. Internet is an efficient way to distribute the geo-information, the State Bureau of Surveying and Mapping has give great effort to settle down the rules and standards to establish the clearing house. Some National Geo-standards have issued, and some of them are on the way. The GIS software is another important factor in the GIS industry. Chinese government working-out some good policy to supports the GIS software developer to have their own copyright. This paper is based on the above to introduce the status and development of Geomatics in China.

Key words: Geo-spatial data, Geo-spatial application, and GIS software development

The Chinese government always attaches great importance to the surveying and mapping industry. Basic surveying and mapping has been formally included in China's annual plan for social-economic development and has been highlighted in China's 10th Five-Year Plan starting from the beginning of the new century. In the last century, significant achievements have been made in China since adoption of the reform and opening-up policy. Geomatics has become a science and technology, which studies how to use spatial graphics to reflect the spatial distribution, correlation, spatial relations and dynamic change of natural and socio-economic phenomena scientifically, abstractly and generally, and how to capture, to build corresponding geographic information to transmit spatial geographic information in the form of graphics and numeral. So far, established the National Astro-Geodetic Network, the National Leveling Network and the National Gravity Network, completed the National High-precision GPS Network, set up the 1:4 million, 1:1 million, 1: 250,000 databases for the National Fundamental Geographic Information System, initiated the development of the 1:50,000 and 1:10,000 databases, and start to update the 1:250,000 database from this year. With applications of remote sensing, GIS, GPS and computer network technologies, SBSM has completed the technological transition from traditional to digital, and established a number of digital production bases.

1. Establishment the fundamental Geo-spatial data framework

Geomatics has become a science and technology, which studies how to use spatial graphics to reflect the spatial distribution, correlation, spatial relations and dynamic change of natural and socioeconomic phenomena scientifically, abstractly and generally, and how to capture, intellectually abstract, store, manage, analyze, use and visualize spatial geographic information, and how to build corresponding geographic information system to transmit spatial geographic information in the form of graphics and numeral.

1.1. Study on map pattern recognition and data capture based on scanned map

Currently, map data is also the fundamental spatial data source of Geography and GIS. Map pattern recognition is the kernel of map digitizing based on scanned image. Data capture system based on scanned maps and nautical chart digitizing system based on scanned images have been established, which play important roles h the geo-data capture and updating.

1.2. Study on high accuracy data capture and updating in Wide Area Differential GPS (WADGPS)

GPS measurement is an important data source and an important means of data updating in Cartography and GIS. Now it is being researched how to setup Wide Area Differential GPS. Network which can make the real-time positioning accuracy of single receiver reach the level of 15 meters, and thus can meet the accuracy demand for data collecting in setting up medium and small scale GIS; at the same time, fast, high accuracy phase differential GPS technique is also being researched, which can attain a positioning accuracy superior to centimeter and for this reason is very meaningful for data collecting in large scale GIS.

1.3. Study on data collection based on full digital photogrammetry system

Digital photogrammetry technique can satisfy the data demand for 3D GIS and 4D GIS. Today, China uses her own software to do aero-triangulation based on GPS full automatic point transference, to create Digital Elevation Model (DEM) and Digital Ortho-photo(DOQ) automatically, to do digital mapping semi-automatically in the form of interaction between man and machine, and it is being researched to make fast spatial data updating in GIS environment (vector graphic data) using digital Ortho-photo.

1.4. Study on using Remote Sensing (RS) images to update spatial data in GIS environment

It has great significance for the correction of GIS spatial data to utilize Remote Sensing (RS) images to update GIS spatial data. The thought of "integration-cone" is put forward based on the integration of GIS and RS, which adopts cooperation between man and machine to actualize automatic, semi-automatic extraction of line-shaped, area-shaped objects, so -Remote GIS integrated software takes shape, and GIS spatial data can be updated; a GIS aided classification method of remote sensing images based on knowledge is proposed.

1.5. Study on data accuracy in GIS

The accuracy of the data m GIS influence its application results. Various factors affecting the accuracy of map digitizing based on scanned images are explored; the influences of the errors of orientation points and sampling points on the digitizing results are analyzed in detail, and an algorithm of automatic aiming at orientation points and sampling points are offered to ensure the accuracy of digitizing results to meet the accuracy level of GIS; the position uncertainty models of line primitives in vector GIS are made, and a set of accuracy indicators for point and line features are presented; the complexity of the digital curves could be measured by four indicators, and the separation of stochastic part from trend movement m error modeling could be realized by using the spline function approach; the error problem of logical operations for GIS attribute category data has been described, and the error propagation and the accuracy of Boolean logic operators (AND,OR and NOT)have been analyzed. The exploitation and process of multivariate of data source and technology system of data Capture /updating promote the construction of map database.

1.6. Major digital map products

After near 20 years' efforts, China National Spatial Data Infrastructure (NSDI) has been formed. Several small and medium scale National level databases have been established. 1:4 million, 1:1 million, 1: 250,000 and partial 1:50,000 databases for the National Fundamental Geographic databases have been finished. With the development of digital mapping technique and the increasing of society demand, the digital map production of China has yielded plentiful fruits-The first generation digital map product, 1:1,000,OOO scale digital map of China (International Edition),has been provided to society formally, which reflects the conditions of natural geography and socio-economy of China. As a result, it is an indispensable digital geographic information product for planning and management, production and construction, scientific research and teaching. The 1:25,OOOmap database of China has been accomplished, which signifies the higher level of National Spatial Infrastructure Database. The experiments of l:50,000 4D products have been completed and the technical scheme has been laid down 1:50000 Digital Raster Graphics (DRG) and 1:50000 Digital Elevation Model (DEM) databases have established recently which will be provided for society recently. More 14,000 1:1,OOOscale DEM products of the seven great rivers have provided much-needed digital products for the rebuilding after flood, which has great significance for water conservancy and flood prevention departments to analyze the forming, joining, releasing of the flood and lay down the flood prevention schemes.

2. Exploitation and progress of Geographic Information System (GIS)

In resent years, China has made greater progress such as theory research, software development, generalization and application m GIS.

2.1. Study on GIS software

Currently, foreign commercialized software, such as ARC/INF0, MapInfo, MGE are still popular in Chinese market. But in resent years, GIS software with Chinese copyright has appeared in the market. In the years 1996,1997,1998, the tests on GIS basic software and fringe software have been organized in Peking by CAGIS and CPGIS, two oversea academic groups, and some GIS software (e.g. MapGIS) has been recommended, which presents the strength of Chinese GIS software production. Generally, the gap

between Chinese GIS software and foreign commercialized GIS software is reducing. In some ways, the former is equal to the latter, and some function modules of the former have surpassed the latter. Now some other GIS software is being developed. All of this signify enormous strides have been made in the development of Chinese GIS software.

2.2. Study on GIS data model and data structure

This has been given a rousing attention by Chinese scholars in resent years. The main gains include: aiming at the drawback of traditional relational model for complex feature, an object-oriented model for spatial data has been presented and demonstrated an use all model for the description, organization and management of complex feature; an Object-oriented GIS data model based on relational database is given; the relation foundation of NINF (non first a normal form) of vector spatial-temporal data model is discussed; three integration plans based on the characteristics of 3D spatial data and data model have been put forward, and they are the integrated model based on TIN and CSG(Construction Solid Geometry. Which is used m urban 3D GIS, the hybrid data model based on Octree and Tetrahedral Network (TEN), which is used in the fields such as geography, marine, the general 3D spatial model based on vector and raster integration; a 3D topological data model based on space partitioning is offered, at the same time its data structure and the methodologies for space partitioning of 3D objects is proposed; aiming at the spatial objects oriented in underground coal mine mining have the features of gray and dynamic change, the data model which is applicable to coal mine GIS is presented; in order to represent the temporal phenomenon of spatial objects, an object-oriented spatial-temporal data model in GIS is put forward, which can stamp a version information on attributes, so the attribute values of an object m different periods can be described directly; a temporal geo-data model wi1h timestamp on the group of synchronous changing data items and the segmented topological arc is given.

2.3. Study on spatial data query languages

Spatial database in GIS is a Kind of special database, and the spatial database query language. Must be equipped with the feature of understanding "spatial concepts". Aiming at the limitation of relationships database structural query language SQL used M spatial data querying, the features of spatial database structural query languages are studied; an approach for representing fuzzy query via Extended SQL(ESQL)is presented, which is then implemented by being transferred into standard SQL; the visualization of spatial information based on multimedia technique is researched, a new Visual Query Language on Spatial Information (SIVQL)is extended and constructed, and the user can query spatial information on graphics or diagrams directly only with the help of mouse and button, and the query results can be shown for user in multimedia forms of graphics, diagrams, texts, images, voices etc.

2.4. Study on spatial data analysis in GIS

It has been paid more attention to improve the function of GIS spatial analysis m resent years. The main manifestations include: aiming at the fuzzy problems on the spatial phenomenon distribution and spatial information analysis, the application of fuzzy analysis in the spatial information analysis is explored, and the conception of fuzzy area and its measuring method, synthesis of the incorrect spatial relation and the application means on fuzzy inference m spatial information analysis have been given; a fuzzy overlay analysis model and its implementation process is proposed, which includes the determination of membership value; a GIS spatial operation based on morphological transformations is presented, which

includes overlay, buffering, proximity analysis and measurement, and morphological algorithm for the shortest route of network is also given; starting from the views of economizing in memory space and increasing operation speed, the algorithm of adjacent nodes is put forward to End the shortest route, and the Object-oriented practicing method is also given; an algorithm of determining a center's service area based on geographic networks is shown; the fast computation of designed-discharge of sewage pipe system under GIS environment is of offered; adjacent analysis is made with GIS, and equidistance buffer and contour method as well as its application in urban road planning and community facilities planning are given; in order to analyze the pollution of lakes scientifically, a

2D diffusion model of water quality and its solution have been explored; the automatic creating model of dynamic buffer is proposed; geographic network analysis in GIS is studied thoroughly, and network analysis model is given; applied model and its management in GIS is discussed; the establishment, management and application of spatial analysis model base in GIS is advanced.

2.5. Study on component GIS(comGIS)

With the development of information society, the requirements of GIS software arc rising rapidly, and how to develop the productivity and musing has become an urgent problem. Componentization has become a new development trend. In this aspect, the main achievements include: based on vector graphics distributed model, the Internet GIS possessing component construction has been developed with Java and JDBC, which include data management component, spatial query component, data acquisition component, thematic mapping component and display component; using comGIS technology , component GIS-Active Map is developed, which possesses 25 attributes, 140 methods and 13 events, and on this basic platform, Hong Kong General Geographic Information System is set up. Furthermore, the development model of Geographic Information System Shell (GISS), geo-information sharing and opening geographic information system and WebGIS programming technique have been explored.

3. Study on '3S' integration theory

The integration of Global Positioning System (GPS), Remote Sensing (RS)and Geographic Information System (GIS)is an issue involved in a wide fields of earth system science. Generally speaking, the integration of "3S"is still in the phase of theory research. For example the main technical means through which the earth system science is proposed include GPS,RS and GIS, what is called "3S"technologies, or we can say the research means of the earth system science is the satellite observing earth system which consists of GPS, RS and GIS; the integration of GPS, RS and GIS has been studied on its definition, contents and methods, according to the features and demands of digital battlefield, the "3S"integration ways have been put forward. The application of "3S"technologies have achieved good results in flood prevention monitoring in lake area, and "3S"technologies are also widely applied m the electronic map navigation positioning. Moreover, aiming at debris simulation particle model system and raster GIS(ERDAS), from the aspects of the automatic collection of model parameters, system integration model, operation environment, time and information expression, multi-temporal process data management, process visualization and spatial analysis, the integration between GIS and 2D debris simulation models has been studied.

4. GIS Application

Many application GIS project for special purposes have been established in China which have been widely applied in macro-scopical policy-making of government agencies; boundary information management, urban planning and management (Beijing, Shanghai, Shenzhen, Guangzhou, etc.), urban society peace (Zhengzhou, Shijazhuang, etc.) , urban water Supply and urban street lamp equipment management (Wuhan) ,environment monitoring and administering (loess plateau, Jingiang district of Dongting lake lower reaches of the yellow river etc.) investment environment appraising (some coastal port cities such as Ningbo, Beihai etc.) disaster prevention and mitigation (earthquake indication forecasting and after earthquake monitoring and rescuing, urban fire fighting etc.), engineering construction (the site selection of major engineering, migration of major water conservancy engineering and its influence on ecological environment etc-k battle command automation and so on. Especially, National Geographic Information System has been set up, which include 1:1,000,000 topographic database of China, 1:1,000,000 place name database of China, and digital elevation model of China. It can provide unified spatial geo-data for each professional information system, and it can also lay the groundwork of spatial positioning for all kinds of data required in national conditions investigating and national economy construction, national macroscopical layout, policy-making analyzing to realize the information sharing, and it has offered information services for many national economy departments.

5. Exploitation and progress of terrain 3D visualization and virtual terrain environment technology

The visualization of spatial information and virtual reality (VR) technology is the new growing point of cartography and GIS, and some theory and technical results have been attained in terrain 3D visualization and virtual terrain environment.

5.1. Study on terrain visualization

In the aspect of theory research, it is proposed that the key research points and development directions will be the Geo-science 3D data model, Geo-Science 3D data field, and the 3D visualization, 3D image surface analysis of Geo-science vector field and Geo-science raster field, real-time dynamic visualization technology; it is emphasized that visualization will effectively strengthen the function of cartography and GIS M the aspects of enhancing the discernment of spatial data complex process analysis, the process and display ability of multi-variables and multi-time data; as for the function of 3D visualization, it is considered that 3D visualization, first of a11,is a spatial cognition behavior, which will effectively improve the result of map information transmission, and explore the new areas of spatial information comprehension; the theory and technique of terrain 3D visualization based on DEM, vector data and remote sensing image is thoroughly studied. The fractal theory is used in terrain 3D display, and the simulation of vegetation veins of terrain surface, and at the same time the corresponding algorithm is proposed to plot3D remote sensing image map, 3D raster terrain map,3D vector feature terrain map, and the principle and algorithm of spatial information querying and operating directly on 3D terrain maps is studied and realized; the multimedia technique concerned with spatial information visualization is studied and the multimedia data model is put forward to realize spatial information visualization.

5.2. Study on VR techniques used in terrain environment simulation

VR techniques expand the spatial cog1ition means and ranges, and change the traditional simulation form, so it gives rise to be attached importance m cartography and GIS fields. The application of VR techniques in operational training simulation is studied, and the operation environment simulation platform sustained by virtual reality techniques has come on, which will become training tools m twenty-first century; the distributed interactive operational training simulation system and the operating terrain environment simulation system have been studied; the organization and management of interactive real-time landscape data model m VR has been researched, and a method of virtual landscape simulation has been given, which is according with the visual sense law, based on map data, and its realization is offered; the technology of simplifying 3D terrain model used m Real-time Operation Environment Simulation System is discussed, and the method of simplifying DTMs and Triangulation Irregular Network TIN model 、 used in landscape simulation is proposed.

5.3. Study on the application of spatial data visualization and VR technique in GIS

First of all, spatial data visualization and VR technique are suggested to be the important technical means in GIS, and it is considered that adopting spatial data visualization and VR technique in GIS cm enable the user to attain required information m the conditions of dynamic, spatial-temporal change, multi--variables, multi-time and interactive maps, and cm effectively improve the transmission efficiency of spatial geographic environment information; then, the relationships among spatial data visualization and VR technique and GIS are studied, and it is considered that GIS sustains spatial data visualization and spatial data visualization improves the function of GIS, and moreover, the integration tactics of spatial data visualization and GIS is put forward. The research on VR technique, especially on Virtual Reality Modeling Language (VRML), will promote the integration of GIS, Internet and Web, and the landscape information can be transmitted in WWW using VRML.

6. Study on theory research of Geomatics

Theory is the forerunner of technologic advancement, and the cartographers attach importance to the theory research of this subject in China. For example, in the aspects such as real map and virtual map, static map and dynamic map, plane map, stereo map, the changes of the varieties of map and its enlightening have been summarized, and based on the changes of the varieties of map, the outlook of cartography striding forward the twenty-first century is discussed. The present situation and frontier of cartography and GIS is also discussed; from four aspects: the key point transferring of cartography-emphasizing geographic information deep processing and practical ultimate product facing to user, the function spreading and extending of cartography –geographic information system, the new growing point of cartography -spatial data visualization and virtual reality, the automation of map production-the historic transform of map production style, the new characteristics of cartography in information times have been analyzed. Moreover, starting with analyzing the essence of modem cartography, the spatial geographic environment information transmission theory, map spatial cog1ition theory and geographic system theory is discussed. And it is considered that to adopt interactive and visualization technique must dissimulate traditional map transmission model. The spatial cognition system of human and cartography and GIS are all information processing systems, so geographic information and cartography and GIS are unified in the aspects such as research objects, thinking modes

and technology systems. Some theory problems directly effecting the development of GIS are discussed thoroughly, which has practical significance to promote the development of GIS. In addition, geo-information on science is initiated, and geo-information science is advocated to be studied as the fundament of modem cartography and GIS; geographic information theory is suggested to be the basic theory of geo--information science, which has guidance significance in deepening the theory research of modem cartography and GIS; the study on interrelation of geographic information provides theory guidance for the organization and the use of geographic information in modem cartography and GIS.

With China's opening-up to the world, The State Bureau of Surveying and Mapping (SBSM), as a government agency, is mainly responsible for the national surveying and mapping administration, and management of basic surveying and mapping. SBSM has, in recent years, increased its cooperation with the international community. We have signed agreements and/or memorandums with the national mapping agencies of over 20 countries for exchange and cooperation, established stable relationship with surveying and mapping institutes of over 50 countries, and kept close contact with over 10 international organizations such as the UN and the ICA. In the new century, SBSM has set the following objectives:

♦ to foster a management system and operational mechanism in the market economy;
♦ to speed up the construction of national geo-spatial databases and data distribution network;
♦ to build the fundamental geo-spatial framework for "Digital China"; and
♦ to meet the demand for geo-spatial information in socio-economic development.

In order to achieve these objectives, we need the support and help from international surveying and mapping community. The twenty-first century will be the century of sustainable development, and humanity will more depend on knowledge innovating and knowledge creativity application. Geomatics will be sure to have a rapid development.

Reference

1. Speech at the Opening Ceremony of the 20th International Cartographic Conference

, By CHEN Bangzhu, president of the State Bureau of Surveying & Mapping; Aug., 2001

2. National Report of China to 11th ICA meeting, The Chinese Society of Geodesy, Photogrammetry and Cartography; Aug., 1999

3. Towards Digital Earth, Proceeding of the Internatioanl Symposium on Digital Earth, Beijing, China Dec., 1999